Technology Town Hall: Natural Gas to Liquid Fuels

Moderators:

Dr. Karma Sawyer, *ARPA-E*

Dr. Robert Conrado, *ARPA-E*

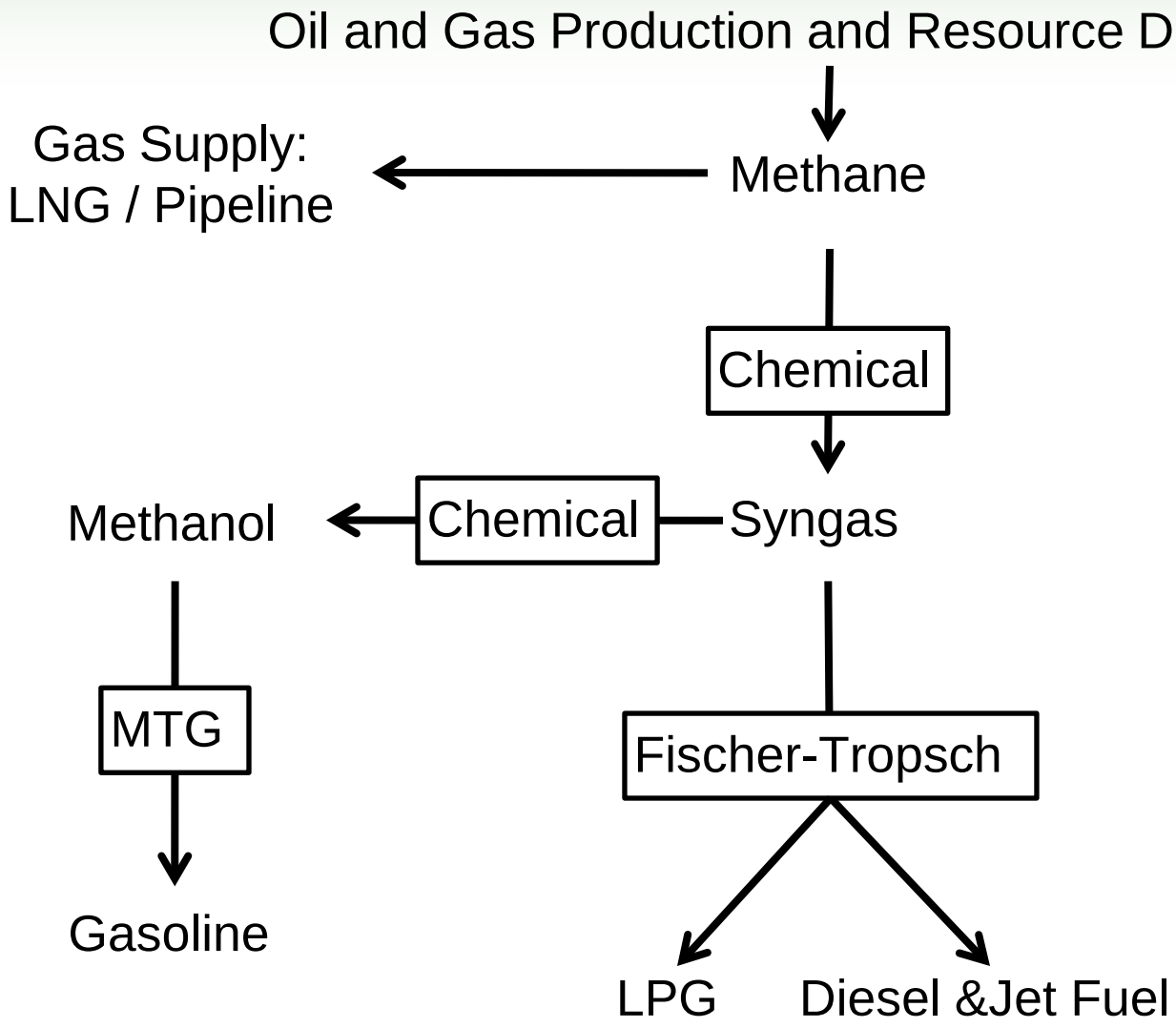
Speakers:

Dr. Donald Paul, *USC Energy Institute*

Dr. Lee Tonkovich, *Velocys, Inc.*

February 28, 2011

Conversion Technologies: Methane to Liquid Fuels



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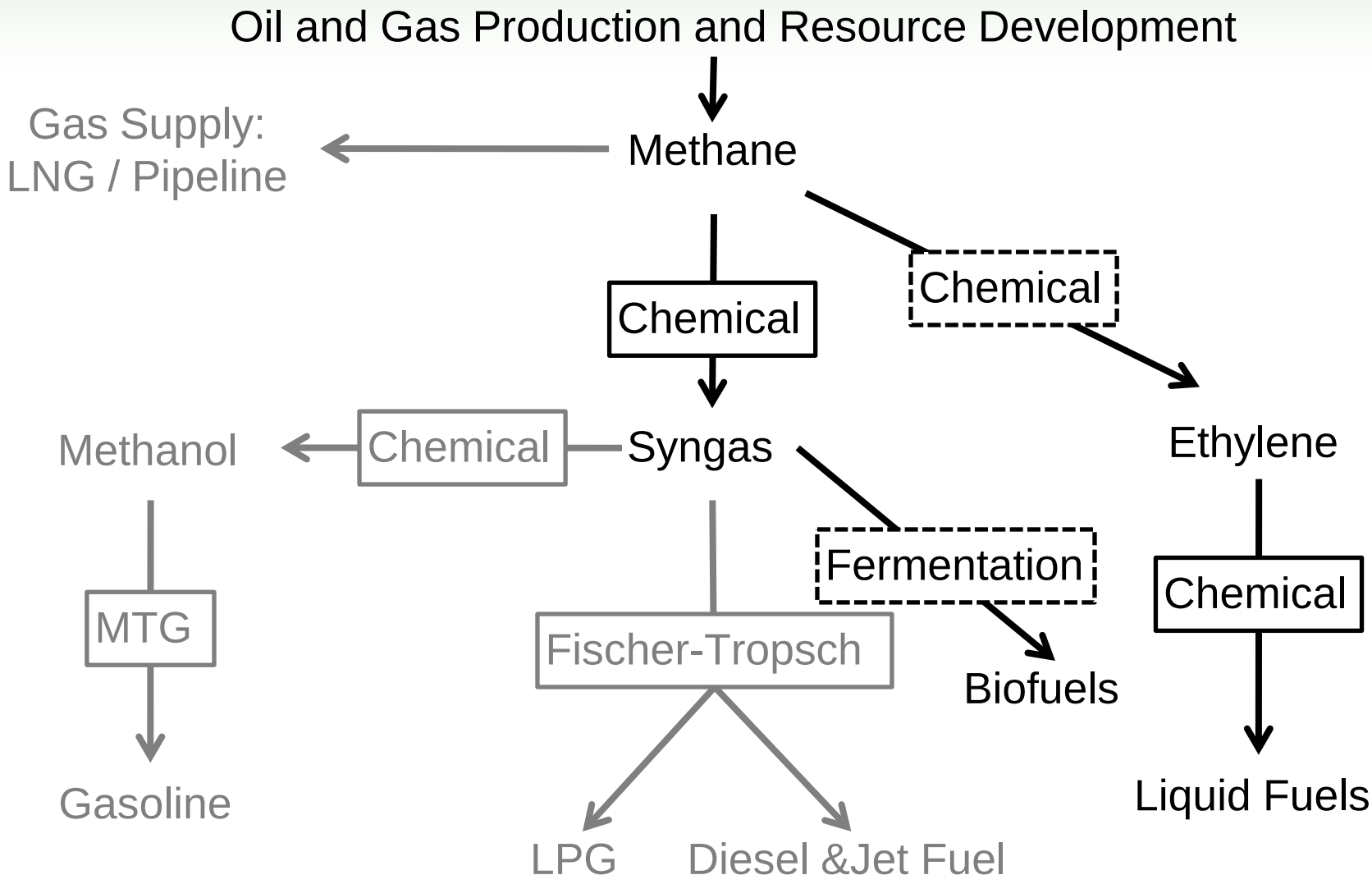

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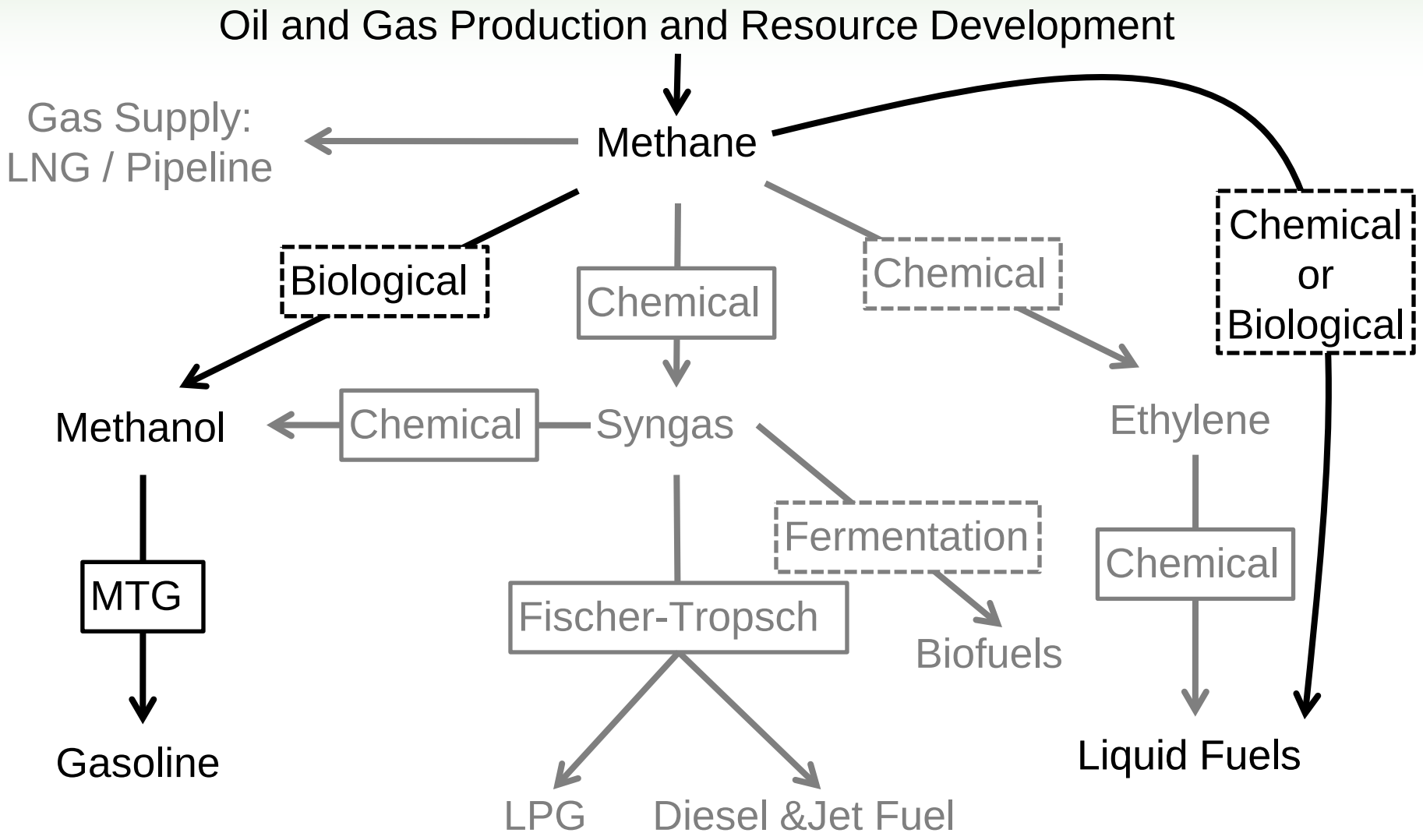

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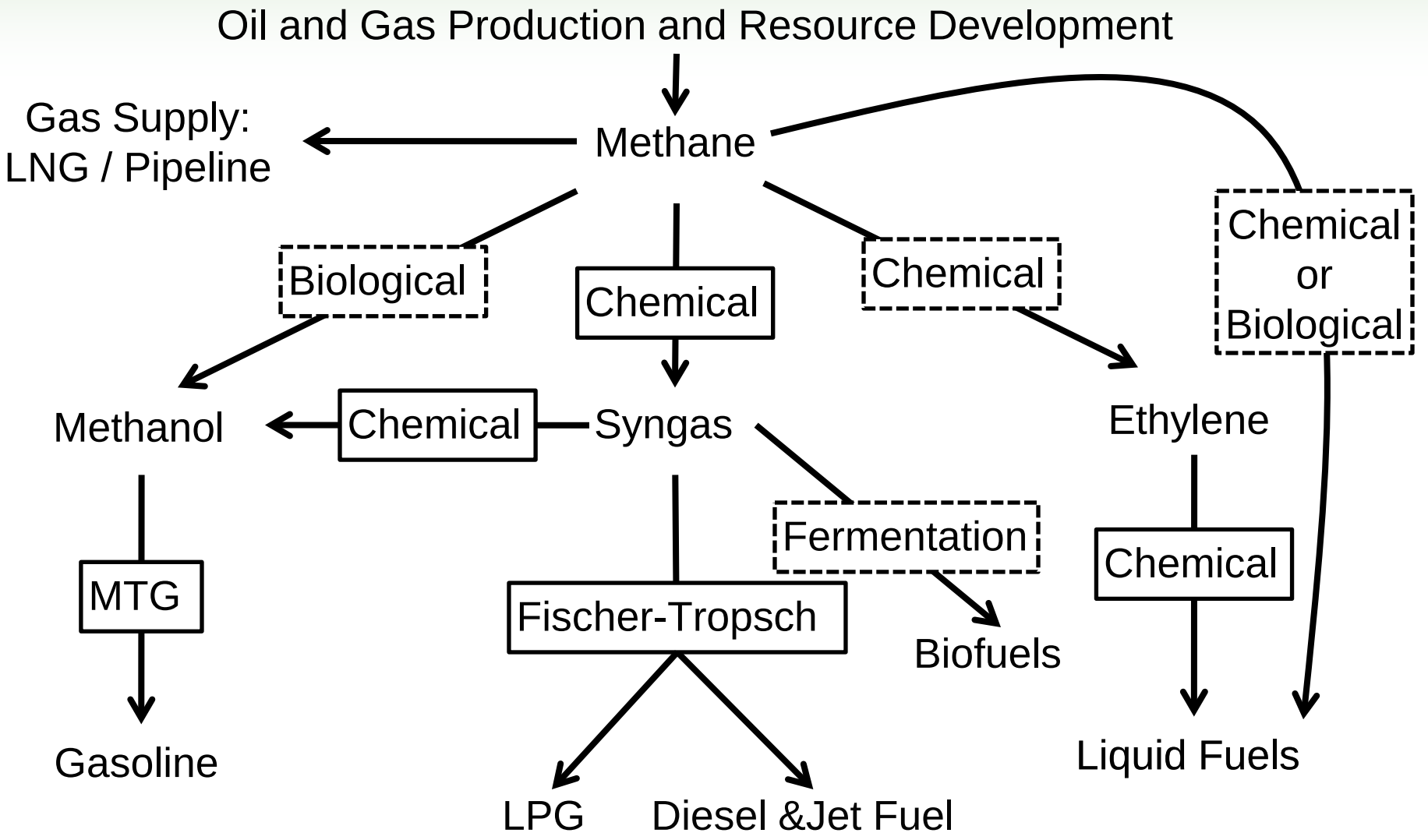


ARPA-E Technology Townhall: Natural Gas to Liquids Fuels Conversion

Resource Development Perspectives on Gas to Liquid Fuels

Dr. Donald L. Paul

Executive Director, University of Southern California Energy Institute and William M. Keck Chair of Energy Resources

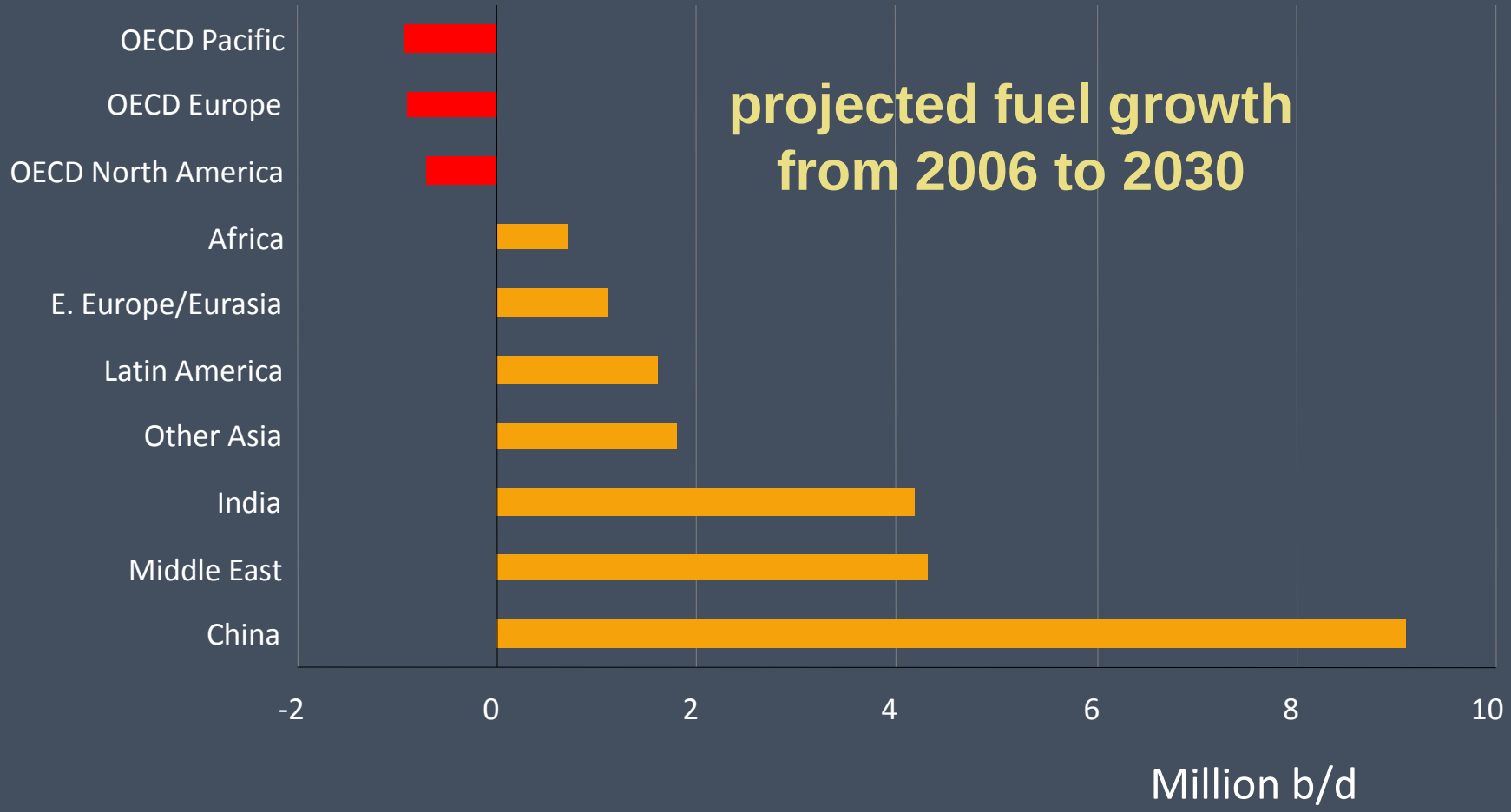
Senior Advisor, Center for Strategic and International Studies

28 February 2011

Outline

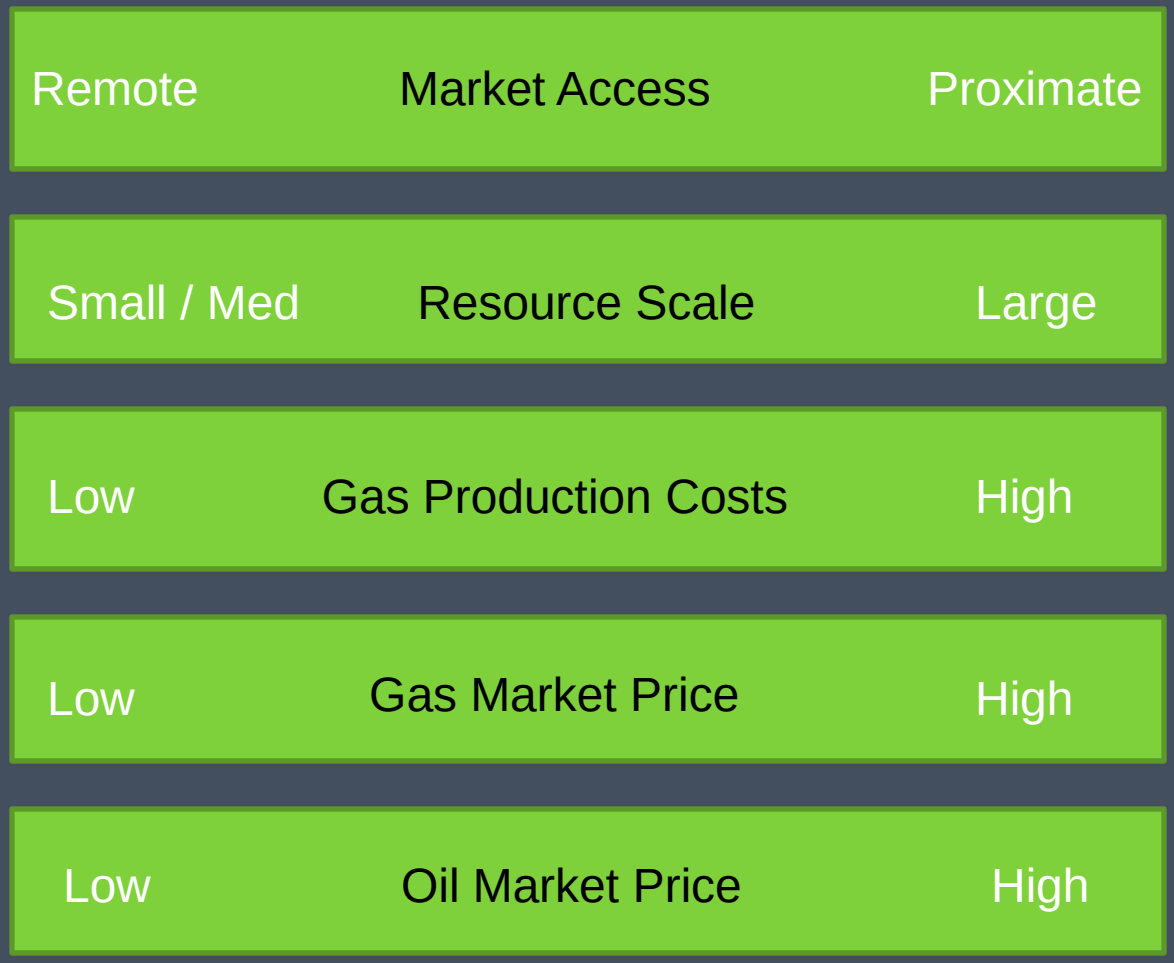
- Why GTL can matter
- Conditions for gas resource and market development
- Conditions for GTL development

Why GTL can matter:
The globalization of liquid fuel demand

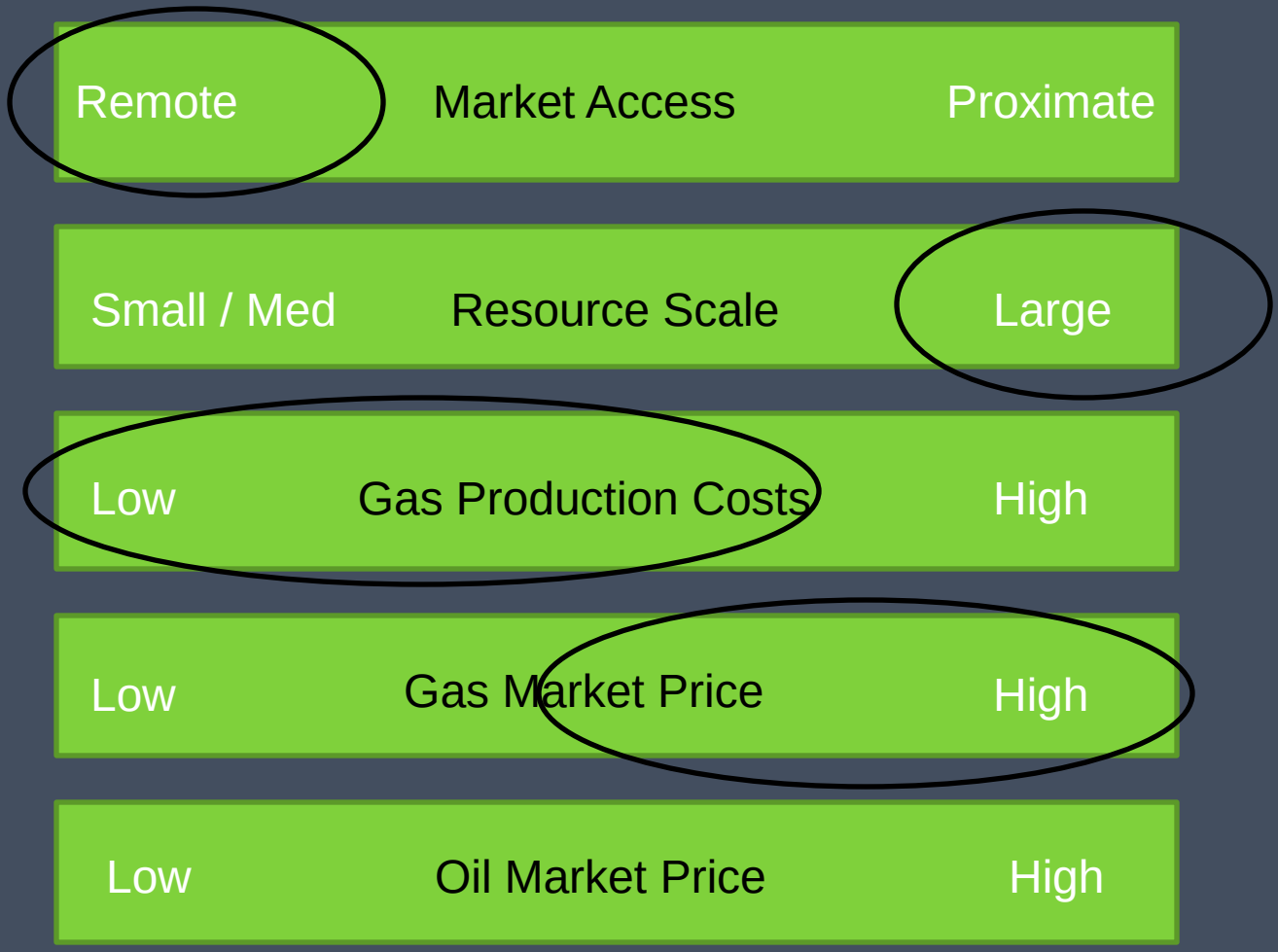


Source: IEA, WEO 2008

Resource and market factors in natural gas development

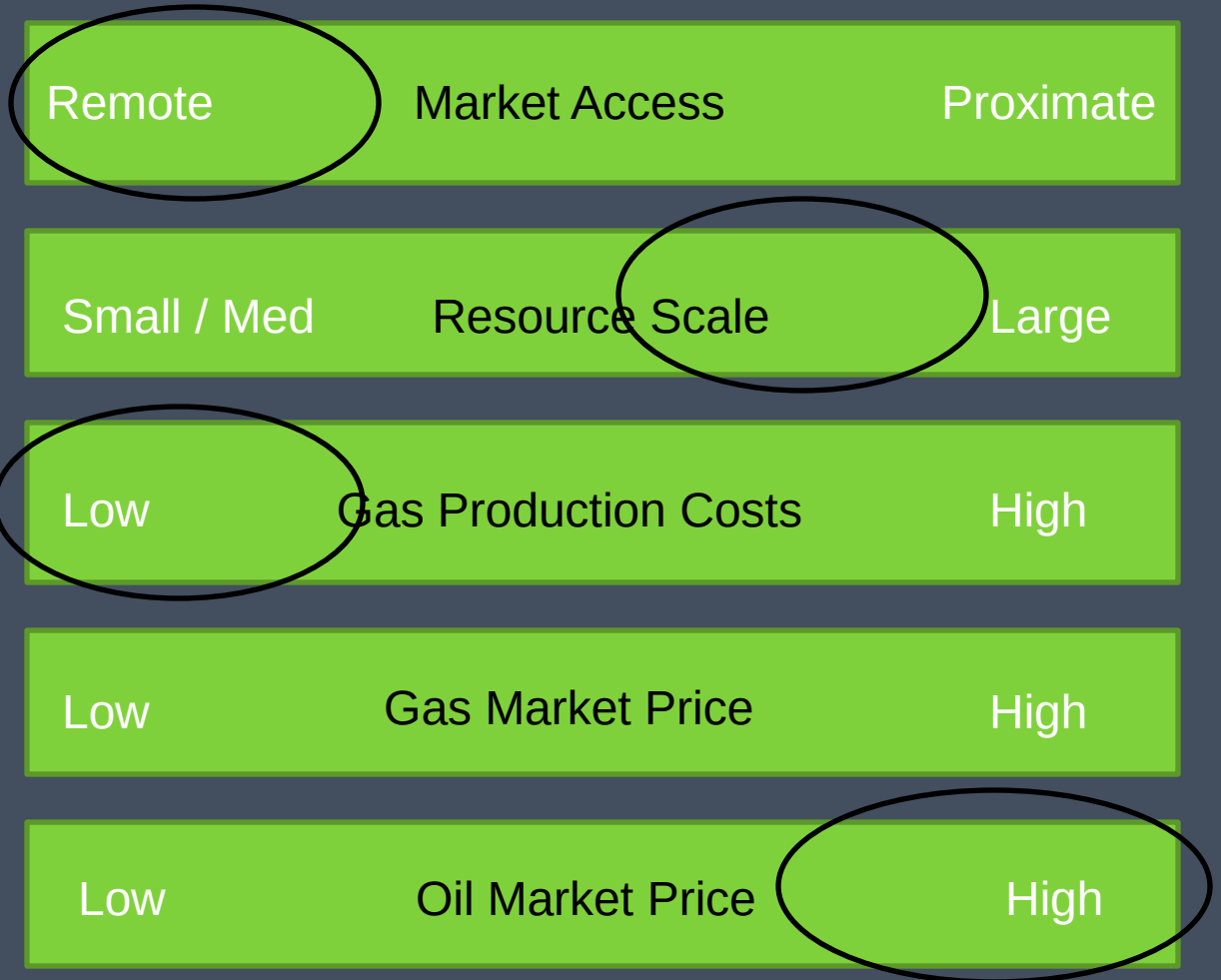


Conditions for LNG infrastructure and market development

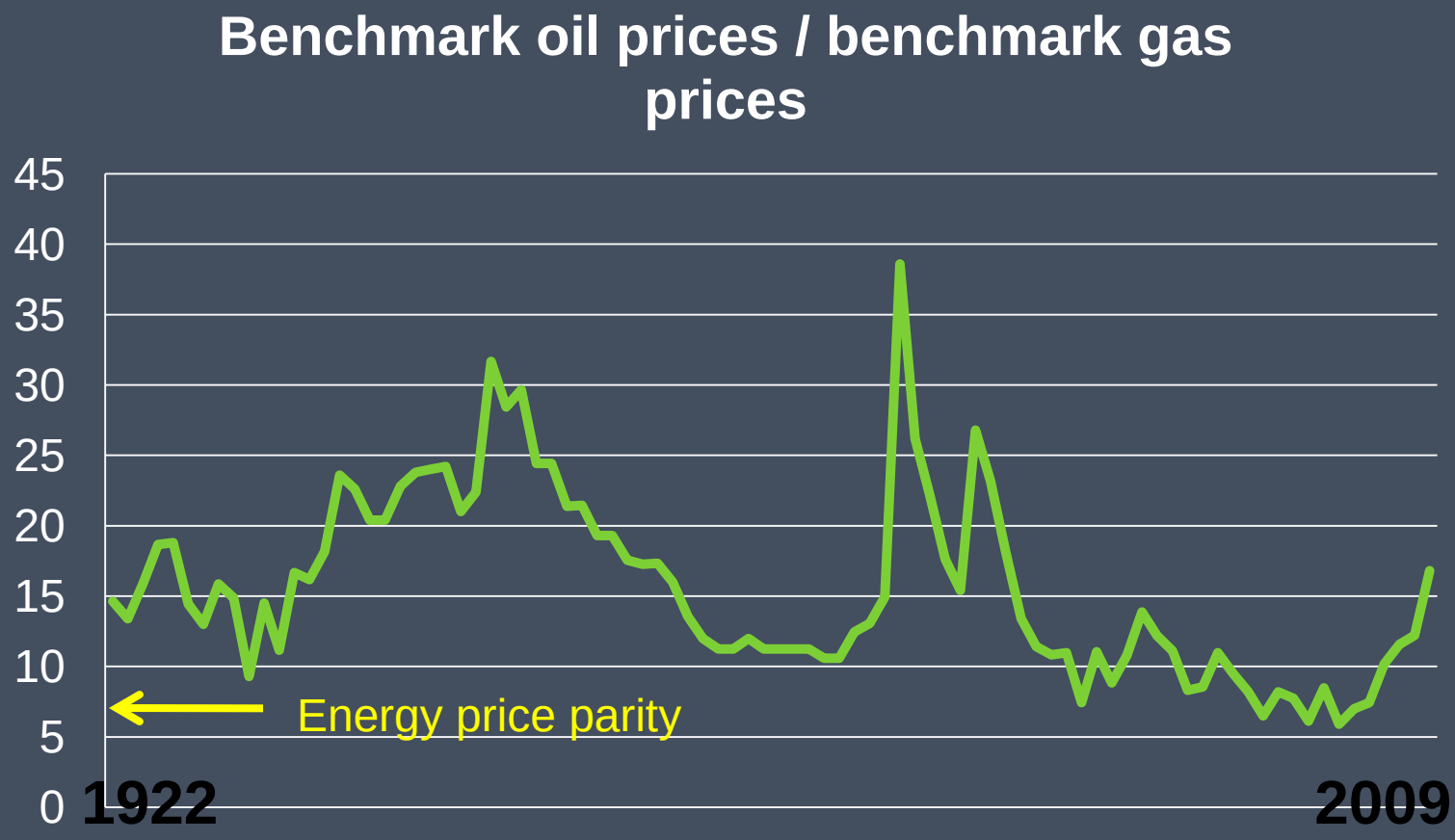


LNG market variations

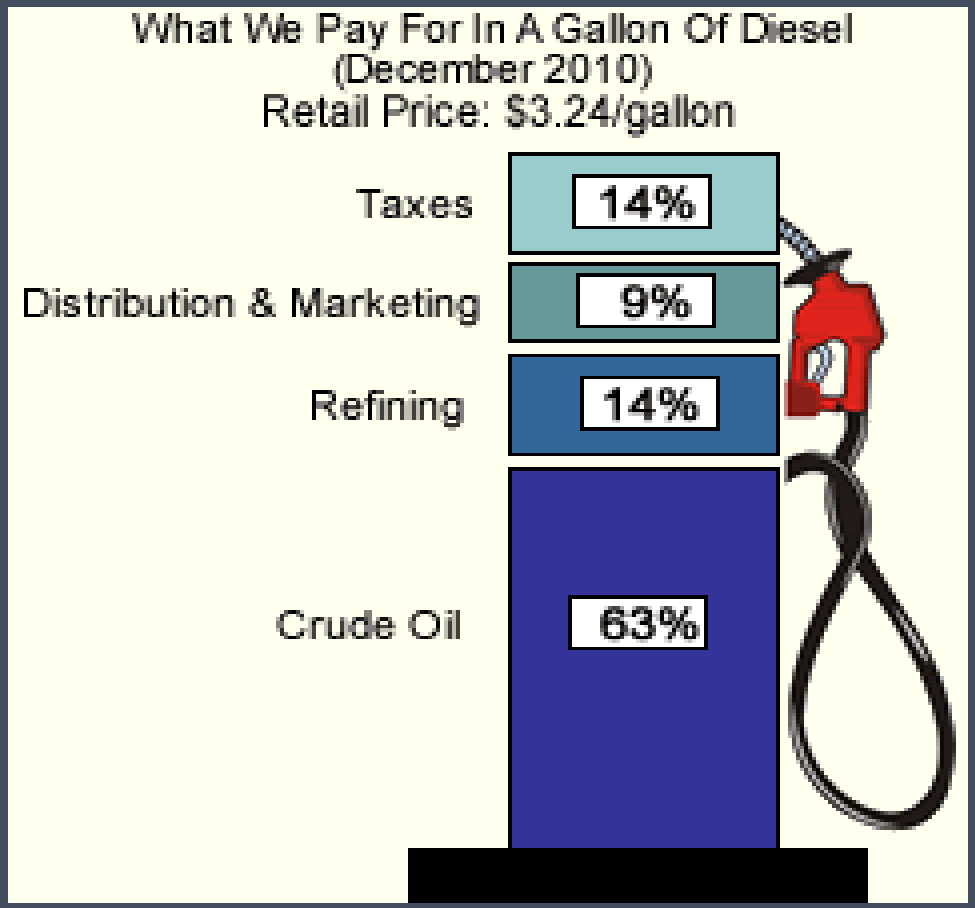
Conditions for GTL infrastructure development



U.S. oil has almost always been relatively expensive compared to gas

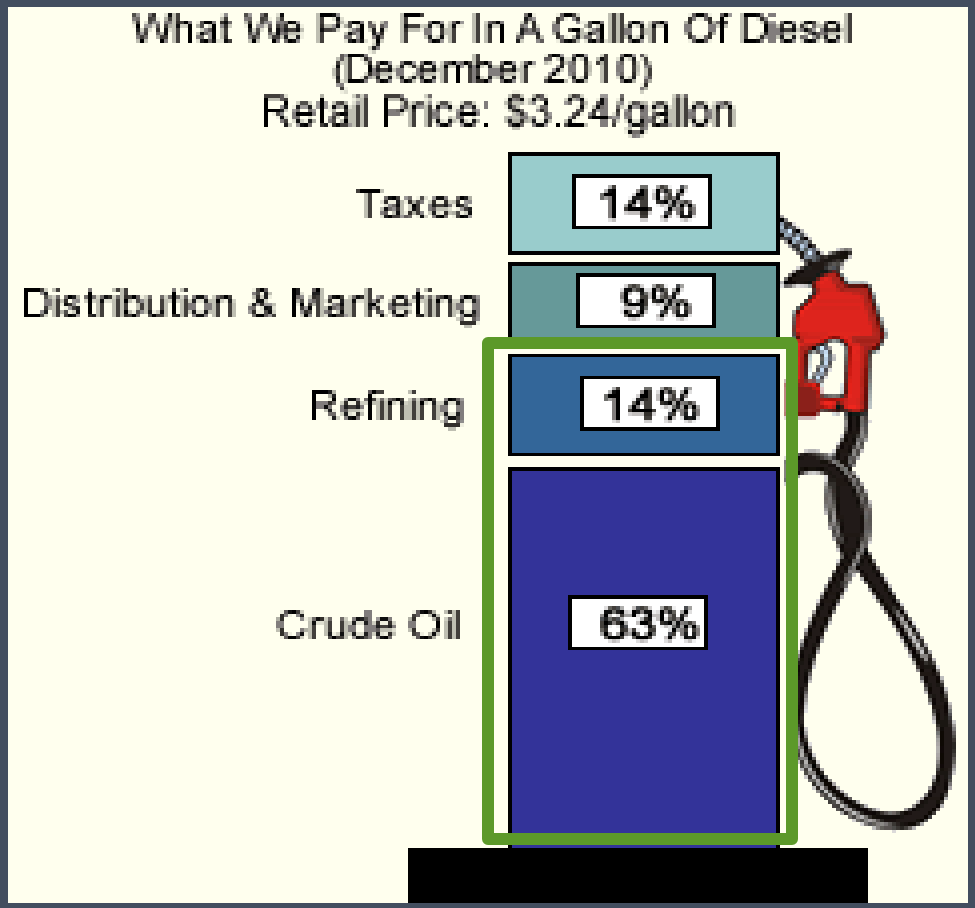


Technology is decisive in making GTL economic



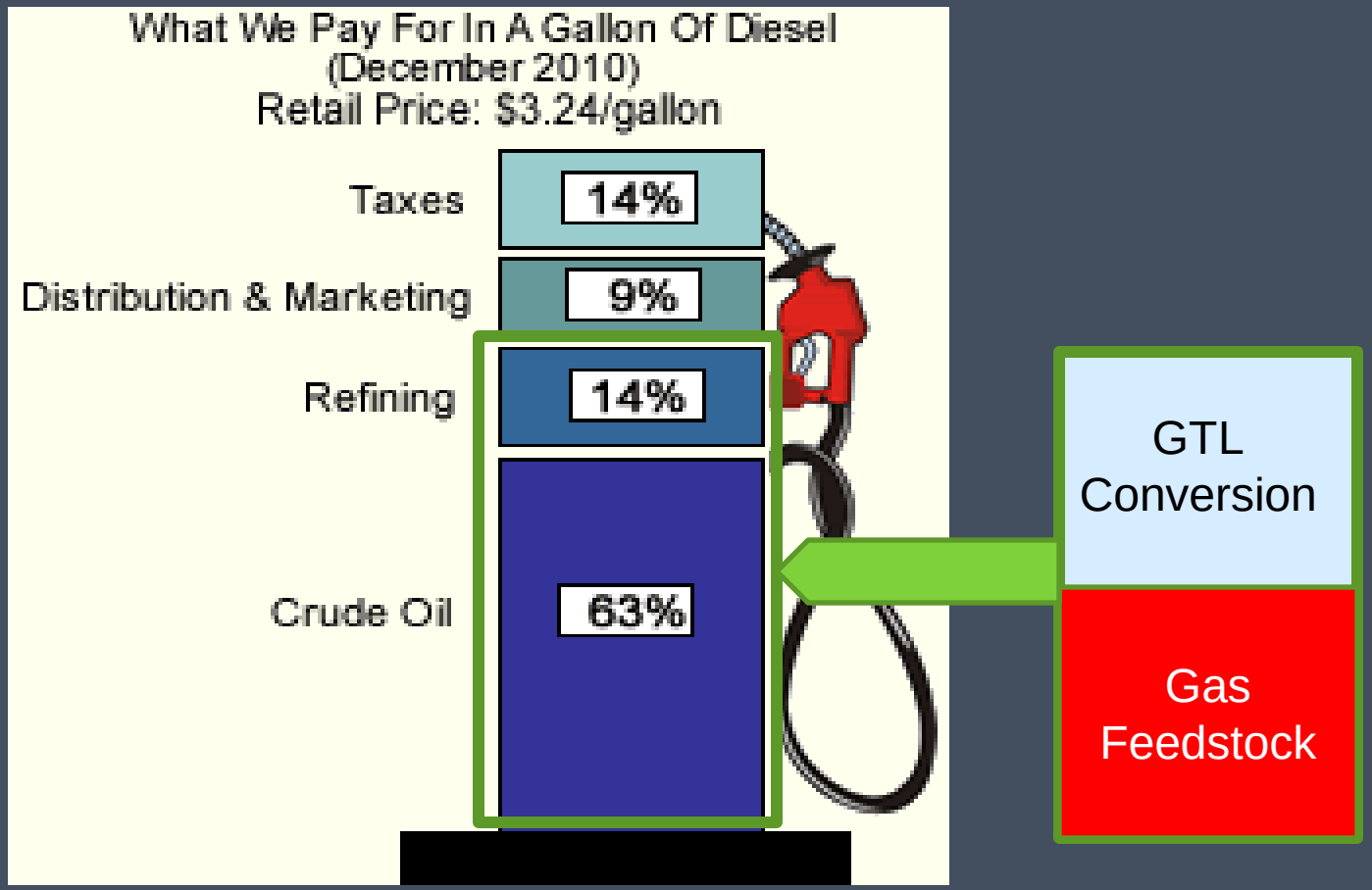
Source: DOE / EIA

Technology is decisive in making GTL economic



Source: DOE / EIA

Technology is decisive in making GTL economic



Source: DOE / EIA

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Distributed Gas-to-Liquids (GTL)
Enabled by Microchannel Technology

ARPA-E Energy Innovation Summit

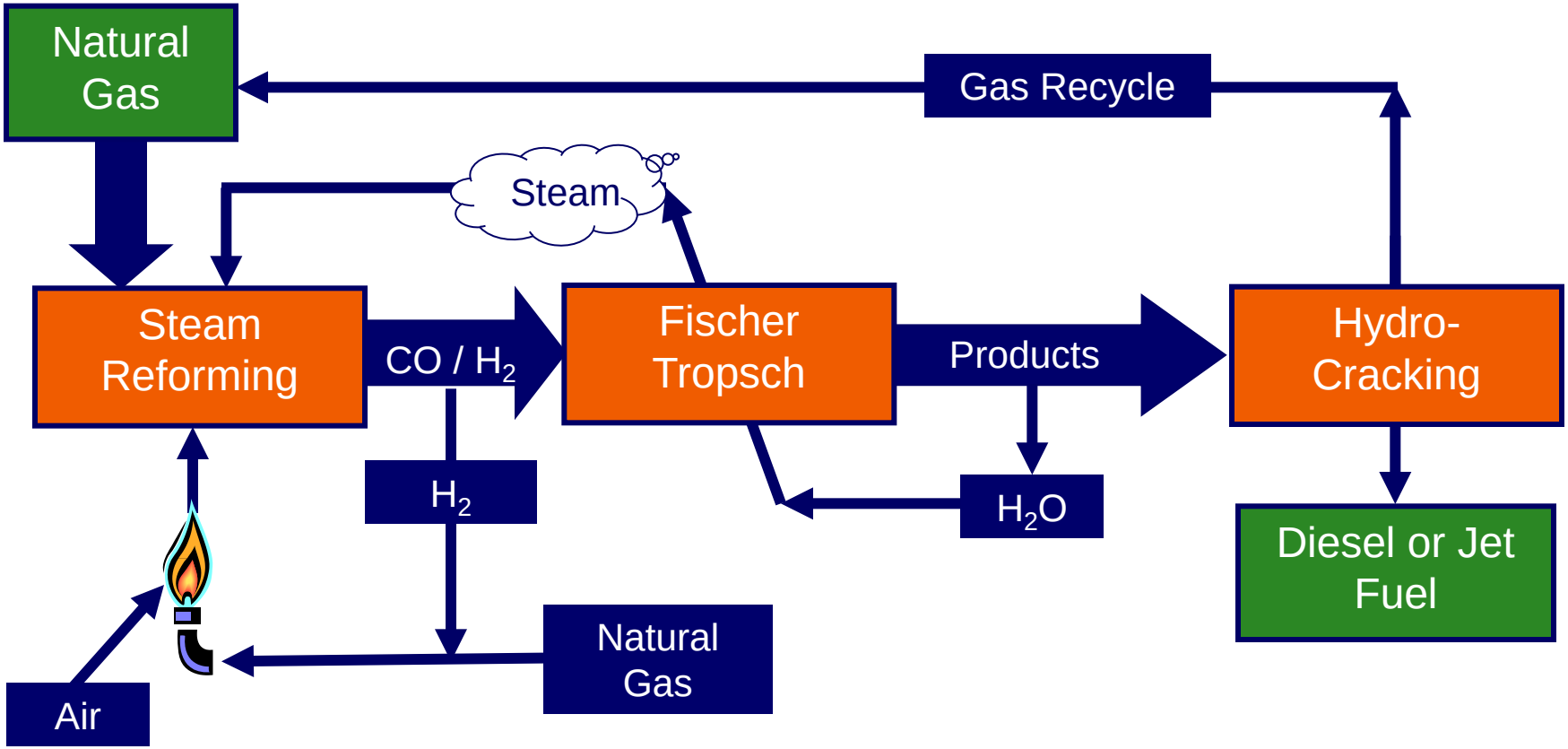
Feb. 28, 2011

Dr. Anna Lee Tonkovich
Chief Technology Officer
Velocys, Inc. / Oxford Catalysts

VELOCYS INC.

GTL Background

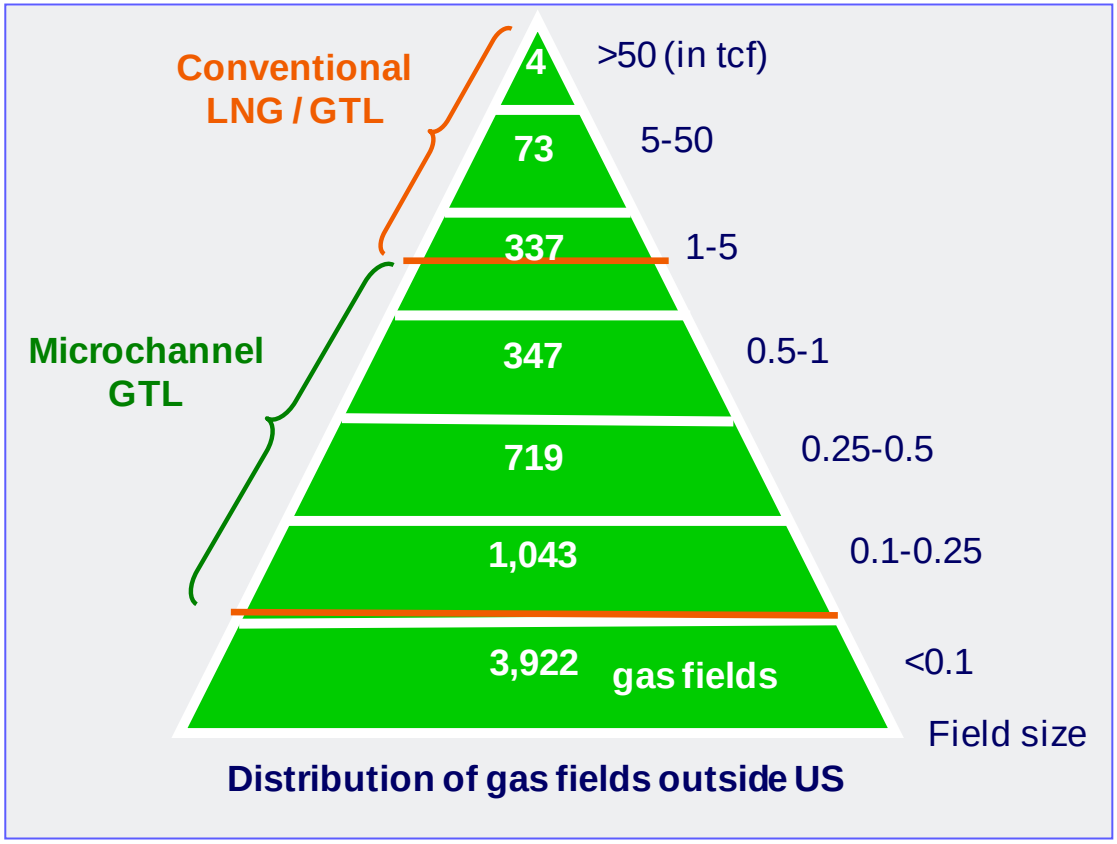
Creating Synfuels using Fischer Tropsch



Market Primed for GTL

- **GTL = Arbitrage**
  - Spread: 1 bbl / 1,000 scf
  - **Opportunity: spread >10**
  - North Am. spread > 20
- **World-scale GTL/LNG plants need large fields**

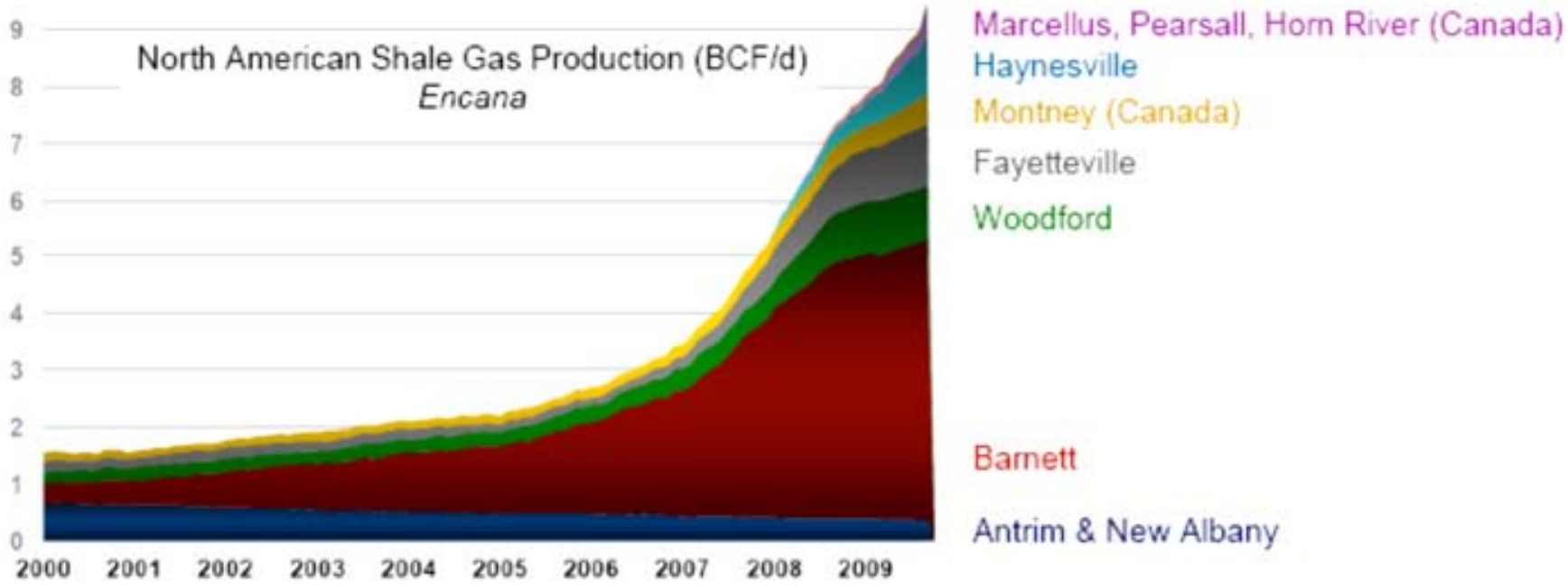
Small-scale GTL can unlock more gas



Source: IHS Energy Group, 1998

U.S. Primed for GTL

- **Shale Gas Production Expanding in U.S.**
  - Production increase: 1.4 TCF (2007) to 4.8 TCF (2020)
  - Reserves estimated at 500 to 1,000 TCF ➔ 50B to 100B bbl oil
  - Worth $3-4T as gas ➔ **liquid fuel value >$10+T**



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GTL Today = World Scale

- **Shell's Pearl GTL in Qatar**
  - ~$19B price tag
  - 140,000 bpd + 120,000 bpd of NGL
- **SASOL Oryx also in Qatar**
  - $1B for 34,000 bpd
  - 60m tall, 2,200 ton reactors
- **Chevron Escravos GTL in Nigeria**
  - $6B, ~4X original estimate
  - 34,000 bpd, using SASOL technology
- **ExxonMobil: Methanol to Gasoline**
  - New Plymouth, New Zealand ('85-'95)
  - 14,500 bpd, 82% gasoline product

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GTL Tomorrow = Small to Medium Scale

- *Tap abundant U.S. gas resources*
- **Large scale economics at smaller capacity**
  - Many, less-expensive plants – **easier to finance**
  - Process intensification for attractive economics
  - Intensify all key unit operations

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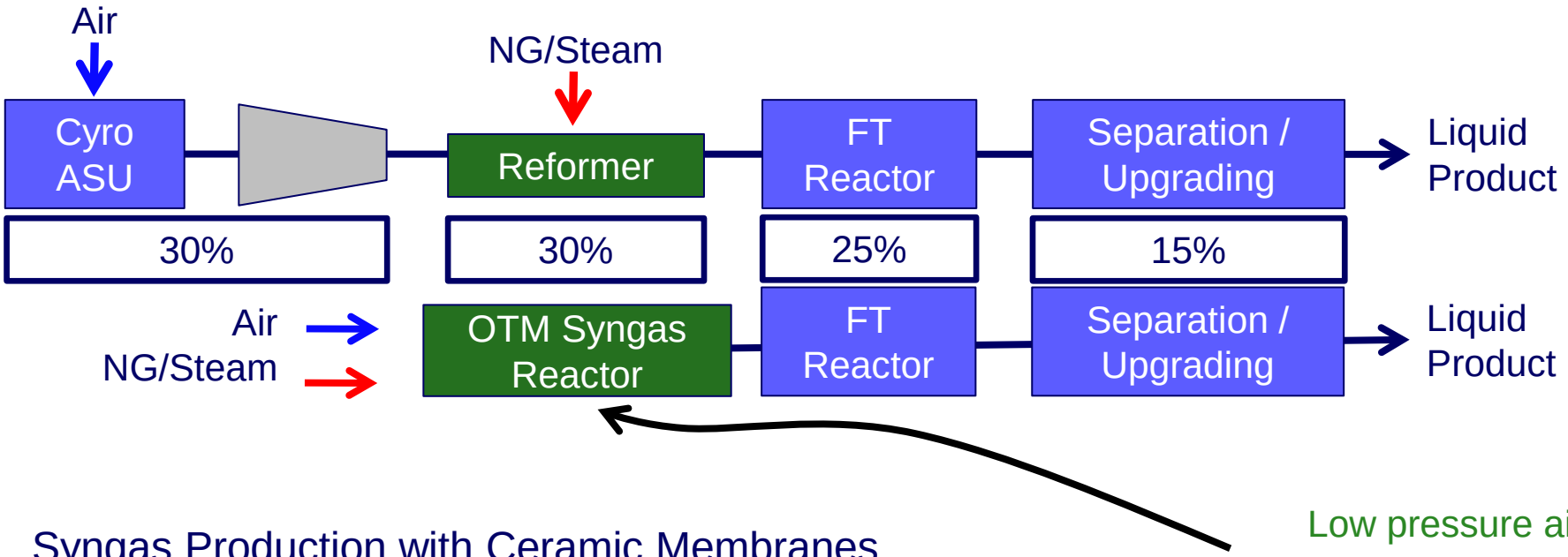
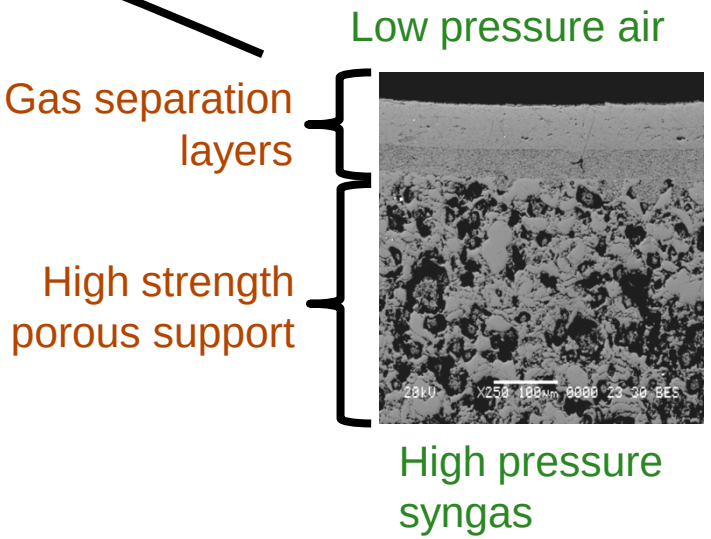
Syngas Production



- Syngas Production with Ceramic Membranes
  - Lower CAPEX/OPEX syngas production
- Status
  - Demonstrated robust material performance
  - Scaling technology to pilot system
- Future (opportunity for ARPA-E support)
  - Integration with FT reactor



Distributed FT

Emerging Fuels Technology (EFT)

- Cobalt-based, fixed bed FT technology
- Selected for two DOE Biorefinery projects
- FT consulting for GTL Projects

Rentech

- Iron-based, slurry bed FT technology
- Process Development Unit (PDU) – 10 BPD in Colorado
- 600 BPD waste/biomass project in Rialto, CA

Syntroleum

- Cobalt-based, slurry bed FT technology
- Bio-synfining process: agricultural feeds to fuels
- Licensed FT technology to China

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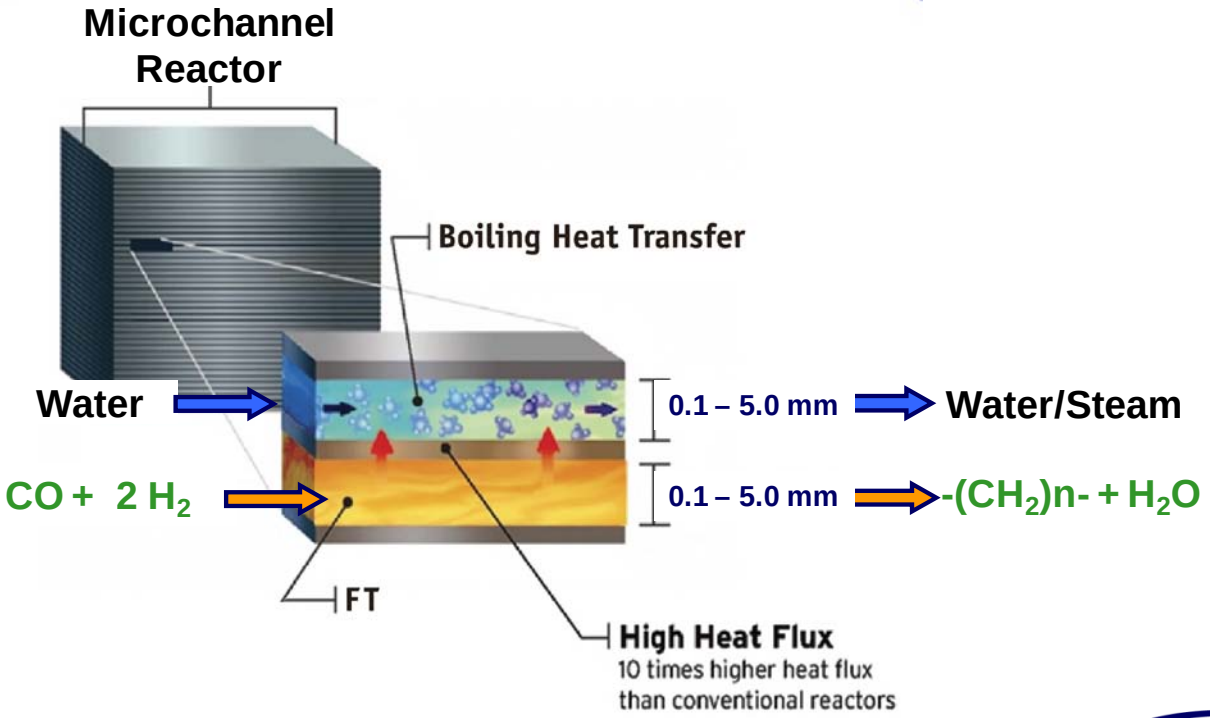
Distributed GTL

Velocys/Oxford Catalysts

- Integrated modular GTL at small to medium scales (SMR + FT + HC)
- Cobalt-based, microchannel FT technology with > 100 US patents
- Established GTL commercial partnerships



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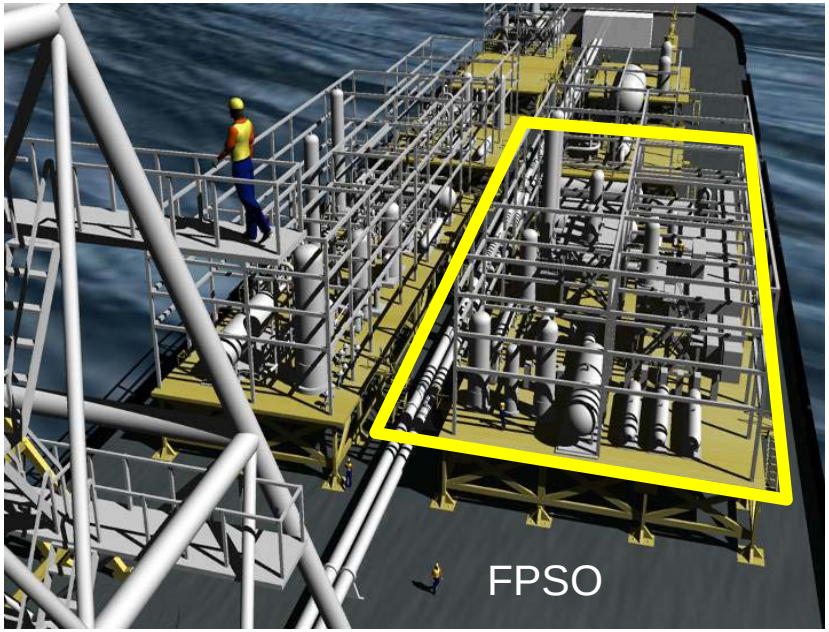
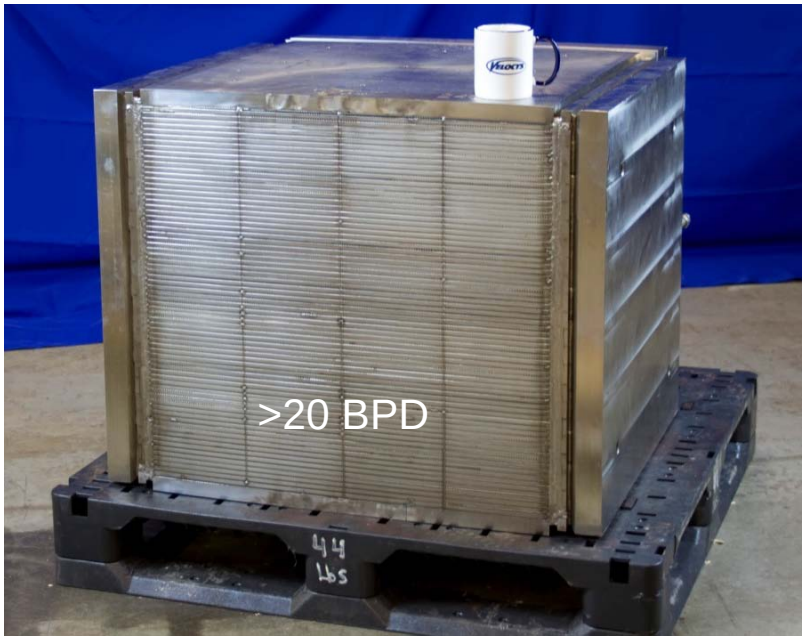
Velocys GTL Demonstration

- Small scale GTL to be demonstrated in **2011** at Petrobras refinery in Brazil
- 6 BPD GTL demo funded by partners





Opportunity

- **Significant gas resources exist in the U.S.**
- **Long-term spread between natural gas and oil prices**
- **Today's GTL technology is for mega-projects**
  - Require >>$1 billion to develop and large resources
  - Difficult to gather enough from shale gas fields
- **U.S. Deployment of GTL technology will require**
  - Modular technologies suited to smaller fields and off-shore
  - Attractive economics at small to medium scale
- **Multiple companies working on enabling technology**

ARPA-E Can Help Lead the Way

- **Strategic development funding**
  - Improve **unit operations** and **system integration**
  - **Leverage** on-going development programs
- **Support process integration**
  - System integration linking new technology and balance of plant
  - Enabling distributed facilities
- **Connect technology suppliers and resource holders**
  - Topical conferences
  - On-line forums
- **Create Grand Challenge Momentum**

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VELOCYS INC.

Questions and Answers

ARPA-E Fellows Office Hours

Today 2:30-5:30 pm (Chesapeake KL)

GTL Networking Session

Tuesday 8:00 pm (Belvedere in the hotel lobby)

Changing the Game in Natural Gas Panel

Wednesday 9:30 am